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### (54) Powder inhalator.

(57) A powder inhalator which is activated by the air flow generated at inhalation and which is intended for inhalation of solid pharmacologically active compound in micronized form, said inhalator comprising a nozzle 2, an air conduit 6, a dosing unit 10 comprising a storage chamber 5 for the active compound and dosing means 8, and a maneuvering unit 1, characterized in that the dosing unit 10 comprises a storage chamber 5 for the active compound, a perforated membrane 4, a holder 9 for the said perforated membrane, and dosing means 8 for introducing active compound into the perforations in the perforated membrane 4, whereby means are arranged for displacing the membrane 4 in relation to the dosing means 8, whereby in a first position solid active compound in micronized form is introduced into the perforations in part of the area of the membrane 4 and in a second position the said part of the membrane 4 is inserted in the air conduit 6 for the air to be inhaled.

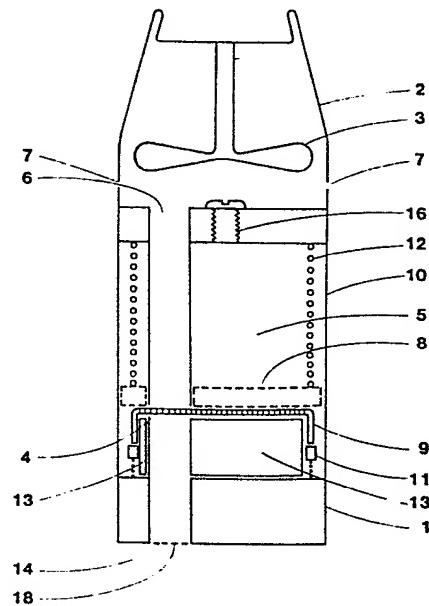


FIG. 1

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Powder InhalatorField of the invention

The present invention relates to a new dosage inhalator, intended to be activated using the air flow generated at 5 inhalation and intended to be used for inhalation of pharmaco logically active compound in solid, micronized form.

Background of the invention

- 10 Special requirements are made with regard to dosage inhalators intended for local administration of drugs to the respiratory tract and to the lungs. Since mostly very potent drugs are to be administered, the dose accuracy must be great. The dosage of active compound that is to be 15 administered may be as small as 0.1 mg. It is also necessary that the particles that leave the dosage inhalator have a suitable size distribution, since too big particles tend to be deposited in the mouth.
- 20 Several systems are available for local administration of drugs to the respiratory tract and to the lungs. Among these systems may be mentioned nebulizing devices, pressurized aerosols, pump inhalators, and inhalators which are activated by the air flow generated at inhalation, 25 herebelow denoted "powder inhalators".

Several types of powder inhalators are available on the market. They represent a complement to pressurized aerosols, where the drug is dissolved or suspended in a liquid 30 propellant mixture. The powder inhalators have the advantage that they always deliver the active compound when the patient inhales, as the particle cloud is generated by the air flow obtained at inhalation. Thereby the problem of coordinating the activation of a dosage with the inhala-



tion in order to bring the active compound to the respiratory tract and to the lungs is solved. An example of powder inhalators which are available on the market is Spinhaler®. In Spinhaler® the active compound is used in micronized form, contained in a hard gelatine capsule which is perforated before use. The hard gelatine capsule is placed in a tube in a device which is brought to rotation by the air flow generated at inhalation, whereby the micronized compound is moved into the air stream and is brought via the air flow to the respiratory tract and lungs of the patient.

However, the previously known powder inhalators have disadvantages:

- 15 1) they cannot be used for accurate and reproducible dispensing of micronized active compound in amounts below 15-20 mg, and they are therefore useful only for less potent active compounds or for highly potent active
  - 20 2) they are cumbersome to load and to make clean;
  - 25 3) usually several inhalations are required to empty a capsule containing a unit dose;
  - 30 4) they are difficult to handle for patients with reduced breathing capacity or with reduced capability in the use of their hands;
  - 35 5) lactose, the diluting agent, is very disturbing at inhalation and may cause increased frequency of caries.
- There is a need for an effective powder inhalator which is activated by the air flow generated at inhalation, which is easy to handle for the patient, which allows dispensation of active compound in an amount down to 0.1 mg



without need to include any diluting agent, and which gives a suitable size distribution for the particles which are administered.

5 The invention

The present invention relates to a dosage inhalator, a so called "powder inhalator", which is activated by the air flow generated at inhalation, and which makes it possible 10 to dispense solid active compound in micronized form, in a suitable size distribution, in an amount from 0.1 mg without need for any diluting agent. The dosage inhalator can be constructed for administering active compound in an amount up to 5 mg. It can also, with suitable construction 15 of the dosing unit be used for administering active compound in an amount of 5-50 mg.

The powder inhalator of the invention is activated by the air flow generated at inhalation and is intended for inhalation of solid pharmaceutically active compound in micronized form. As is described in the appended claims, the powder inhalator comprises a nozzle, an air conduit, a dosing unit comprising a storage chamber for the active compound and dosing means for measuring the intended 25 dosage of the active substance, and a maneuvering unit for operating the dosage unit. The powder inhalator is characterized in that the dosing unit comprises a storage chamber for the active compound in combination with dosing means comprising a perforated membrane, a holder 30 for said perforated membrane, means for introducing active compound into the perforations in the perforated membrane, and means for displacing the membrane in relation to the storage chamber, whereby in a first position solid active compound in micronized form is introduced into the perforations in part of the area of the membrane and in a second position the said part area of the membrane is inserted in the conduit for the air to be inhaled.

The dosing means in combination with the storage chamber for the active compound represent the essential new elements in the powder inhalator according to the invention.

5

One embodiment of the dosage inhalator according to the invention is now described more in detail with reference to Figures 1, 2, and 3.

10 Figure 1 is a sectional view through the dosage inhalator according to the invention.

Figure 2 shows scrapers in the storage chamber, which scrapers are used to introduce active compound into the  
15 perforations in the perforated membrane.

Figure 3 shows how the active compound is fed from the storage unit into the perforations in the perforated membrane using the said scrapers.

20

The dosage inhalator comprises a maneuvering unit 1 which is used for feeding dosages of the active compound, a nozzle 2 which may be provided with rotating means 3 intended for disrupting such aggregate particles of the  
25 active compound which might have been formed, a dosing unit 10 for measuring the intended dosage of the active compound and a storage chamber 5 for solid micronized active compound.

30 The dosage inhalator also comprises an air conduit 6 intended for passage of the air to be inhaled. The nozzle 2 can be provided with rotating means 3 intended for disrupting such aggregate particles of the active compound which might have been formed. The disintegration of  
35 possible particle aggregates is facilitated by air inlets 7 arranged at the side of the nozzle 2.



The dosing unit 10 comprises a storage chamber 5 for the active compound a perforated membrane 4, a holder 9 for the perforated membrane, and dosing means 8, schematically shown in Figure 1, for introducing the active compound 5 into the perforations in the perforated membrane 4. The dosing unit 10 and the perforated membrane 4 are displaceably arranged in relation to one another between a first position where active compound by the dosing means 8 is introduced into the perforations in part of the area 10 of the perforated membrane 4, and a second position where the said part area of the loaded membrane 4 has been inserted into the air conduit 6 in the dosage inhalator. In said first position of the membrane 4, the active compound is brought from the storage chamber 5 into the perforations 15 in the membrane 4. When a part area of the membrane 4 containing such perforations filled with active compound thereafter is inserted into the air conduit 6, the active compound contained in the perforations will be entrained at inhalation and be brought through the nozzle 2 to the 20 respiratory tract and the lungs of the patient.

The introduction of active compound into the perforations in the perforated membrane 4 is in the described embodiment made with mechanical means 8 consisting of elastic, spring-loaded scrapers 15, mounted in a holder 17 in the storage 25 chamber 5. See Figures 2 and 3.

In a preferred embodiment, the perforated membrane 4 is displaceably arranged in relation to the storage chamber 5. 30

In another preferred embodiment, the dosing unit 10 comprises a perforated membrane 4 which can be rotated and which is intended to be loaded with solid active compound in micronized form.

35 In a further preferred embodiment, elastic spring-loaded scrapers 15 are arranged in the storage chamber 5 to introduce active compound into the perforations in the perfo-

rated membrane 4.

In another preferred embodiment, the perforations in the perforated membrane 4 are in the form of truncated cones  
5 with their large opening directed to the nozzle.

The scrapers 15 are suitably manufactured in an elastic material, for example rubber or plastic. The scrapers are suitably arranged so that they when the active compound  
10 is introduced into the perforations in the membrane 4 touch the surface of the membrane at an angle which is less than 90°. When the means for introducing active compound into the perforations in the membrane are arranged in this manner, the additional advantage is obtained that possible  
15 aggregates of active compound are disintegrated before administration.

The scrapers 15 are suitably arranged so that they press against the surface of the membrane 4. That is achieved  
20 as shown in Figure 1 by having the scrapers 15 loaded by a spring 12. The spring 12 is arranged in the storage chamber 5 as is shown in Figure 1.

Alternatively, a spring can be arranged so that the membrane 4 is pressed against the scrapers 15. The spring may in such case be arranged outside the storage chamber 5, suitably mounted in the maneuvering unit 1. Further variations are possible. The essential element is that the scrapers 15 press against the membrane 4 in such a way  
25 that active compound is introduced into the perforations in the membrane 4 when the maneuvering unit is operated.  
30 See Figure 2 and Figure 3.

In the maneuvering unit 1, immediately adjacent to the membrane 4, a plate 13 is arranged which prevents active compound from passing through the perforations in the membrane 4. See Figure 1. Thus, the plate 13 will comprise  
35 the bottom of the perforations.



The air conduit 6 passes through the maneuvering unit 1. At inhalation through the nozzle 2 the air flow will pass partly through the air inlets 7 arranged at the side of the nozzle 2, partly through the air conduit 6. The air  
5 in the air conduit 6 passes through its opening 14 in the maneuvering unit 1. In the embodiment shown in Figure 1, a perforated plate 18 is arranged as a filter in the opening 14 in order to prevent undesired particles of larger size from entering the air conduit 6.

10

The perforated membrane 4 in the dosing unit 10 can be made, as is illustrated in Figure 1 and in Figure 3, as a horizontal membrane. But also other embodiments are  
15 possible, for example a membrane in the form of a drum where the active compound is filled into the perforations from a storage chamber which can be arranged outside the drum or inside the drum.

20 When a membrane in the form of a horizontal plane is used, as illustrated in Figure 1, the membrane can be mounted so that it can be moved by rotating it, whereby the other parts of the dosage inhalator are fixed relative to one another.

25

In order to make sure that the amount of active compound that has been filled into the perforations which are inserted in the air conduit 6 is released from the perforations and entrained at inhalation, the said perforations  
30 in the membrane are suitably formed as truncated cones, see Figure 3, with the wider opening directed towards the nozzle. Perforations in the form of truncated cones facilitate the emptying of the perforations in that the active compound is released more easily. Moreover, when the  
35 storage chamber 5 is arranged between the membrane and the nozzle, also the filling of the perforations is facilitated if the perforations are designed as is shown in Figure 3.



The perforations in the perforated membranes can be of arbitrary design. They can be circular, square, elliptic, rectangular or have other geometrical form. The area of the perforations in the membrane can be a large or a small part of the membrane area, for example from 1 to 95 %, whereby the term "membrane area" refers to that part of the area of the membrane which is inserted into the air conduit. The number of perforations in the membrane area can vary depending on factors such as the amount of active substance that is to be administered per dosage, the physical properties of the active substance, etc. In a preferred embodiment the perforations have conical shape.

The perforated membrane can be manufactured in any suitable material, for example metal or plastic. The size of the dosage of active compound which is to be administered is determined by the size of the perforations in the membrane, the thickness of the membrane, the number of perforations in the membrane and by the size of the air conduit. A single perforation may be sufficient for dispensing a given dose of the active compound. The accuracy of the dosage will mainly depend on the accuracy in the manufacturing of the membrane. Examples of perforated membranes that can be used are the metal nets which are manufactured by Veco Beheer B.V., Eerbeek, The Netherlands. These nets can be obtained with various sizes of the perforations. They can be formed in desired manner, for example in drum form or they can be used in the form of horizontal, plane membranes. Also woven nets of metal, fiber or of other materials can be used. The important factor is the dosage accuracy that can be obtained.

The maneuvering unit 1 is in the embodiment shown in Figure 1 arranged adjacent to the dosing unit 10. The maneuvering unit can be made in the form of a dented ring, as is shown in Figure 2, where spring-loaded pins 11, see Figure 1, are used to provide distinct positions for the perforated membrane when it is advanced by operating the maneuvering

unit 1. The maneuvering unit can be arranged also otherwise, for example by arranging it to operate directly on the perforated membrane.

5 The storage chamber is in a preferred embodiment arranged between the perforated membrane and the nozzle. See Figure 1.

10 The storage chamber can be arranged to accomodate a varying amount of the active compound. In a dosage inhalator where the storage chamber is not made for refilling of active compound it can contain an amount of active compound corresponding for example up to about 200 dosage units. In a dosage inhalator where the storage chamber is intended 15 for refilling a device is required which can be arranged on the top or on the sides of the storage chamber. For example, a screw or plug 16 can be arranged in the storage chamber 5 as is shown in Figure 1.

20 The air conduit 6 can have an area of 25-350 mm<sup>2</sup>. The air conduit can be circular or have other geometrical form. If it is circular, the diameter may be from 3 to 10 mm.

25 Among compound groups and specific compounds which are suitable for administering with a powder inhalator according to the present invention can be mentioned

- betareceptorstimulating agents such as adrenaline, isoprenaline, orciprenaline, salbutamol and terbutaline,

30

- steroids for inhalation such as budesonide,

- substances intended for nasal administration.

35 Especially useful are terbutaline and budesonide.



The active compound can be administered in micronized form without additional ingredients or in pharmaceutically modified micronized form in order to obtain improved flow properties. The micronized particles may be covered with a 5 film functioning for example by masking bitter taste of the active compound, or by providing slow release of the active compound in the respiratory tract.

In an additional aspect, the present invention relates to 10 the use of a perforated membrane as dosing means for solid micronized active compound in powder inhalators.

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What we claim is:

1. A powder inhalator which is activated by the air flow generated at inhalation and which is intended for inhalation of solid pharmacologically active compound in micronized form, said inhalator comprising a nozzle 2, an air conduit 6, a dosing unit 10 comprising a storage chamber 5 for the active compound and dosing means 8, and a maneuvering unit 1, characterized in that the dosing unit 10 comprises a storage chamber 5 for the active compound, a perforated membrane 4, a holder 9 for the said perforated membrane, and dosing means 8 for introducing active compound into the perforations in the perforated membrane 4, whereby means are arranged for displacing the membrane 4 in relation to the dosing means 8, whereby in a first position solid active compound in micronized form is introduced into the perforations in part of the area of the membrane 4 and in a second position the said part of the membrane 4 is inserted in the air conduit 6 for the air to be inhaled.

2. A dosage inhalator according to claim 1, characterized in that the perforated membrane 4 is displaceably arranged in relation to the dosing means 8.

25 3. A dosage inhalator according to claim 1, characterized in that the dosing means 8 comprises a perforated membrane 4 which can be rotated and which is intended to be loaded with solid active compound in micronized form.

30 4. A dosage inhalator according to claim 3, characterized in that elastic spring-loaded scrapers 15 are arranged in the storage chamber 5.

35 5. A dosage inhalator according to claim 3, characterized in that the perforated membrane 4 is pressed against scrapers 15 with a spring mounted in the maneuvering unit 1.



6. A dosage inhalator according to claims 3, 4 or 5, characterized in that the perforations in the perforated membrane 4 are in the form of truncated cones with their large opening directed to the nozzle 2.

5

7. A dosage inhalator according to any of claims 1-6, containing terbutaline as active compound.

8. A dosage inhalator according to any of claims 1-6,  
10 containing budesonide as active compound.

9. The use of a perforated membrane as dosing means for solid micronized active compound in powder inhalators.

15 10. A dosage inhalator according to claims 1-7 inclusive and substantially as described.

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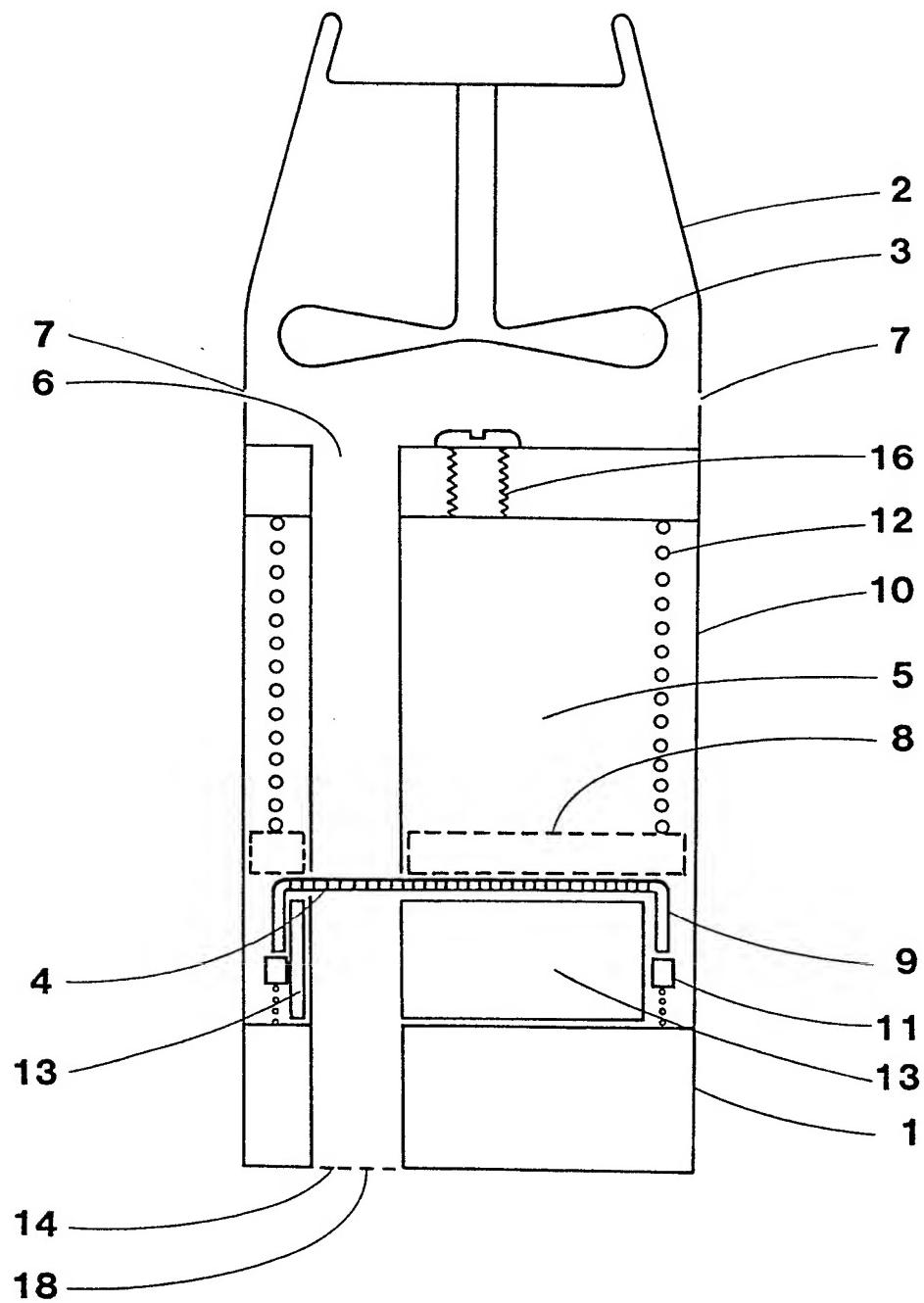


FIG. 1

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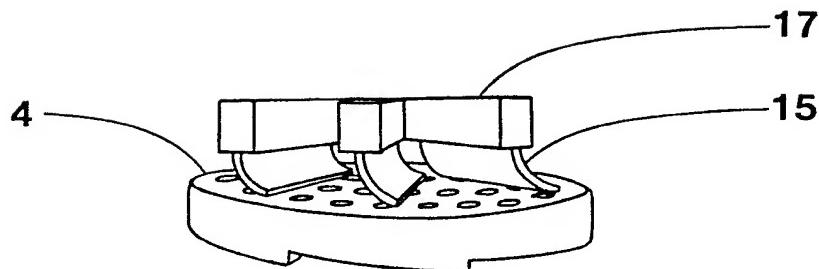


FIG. 2

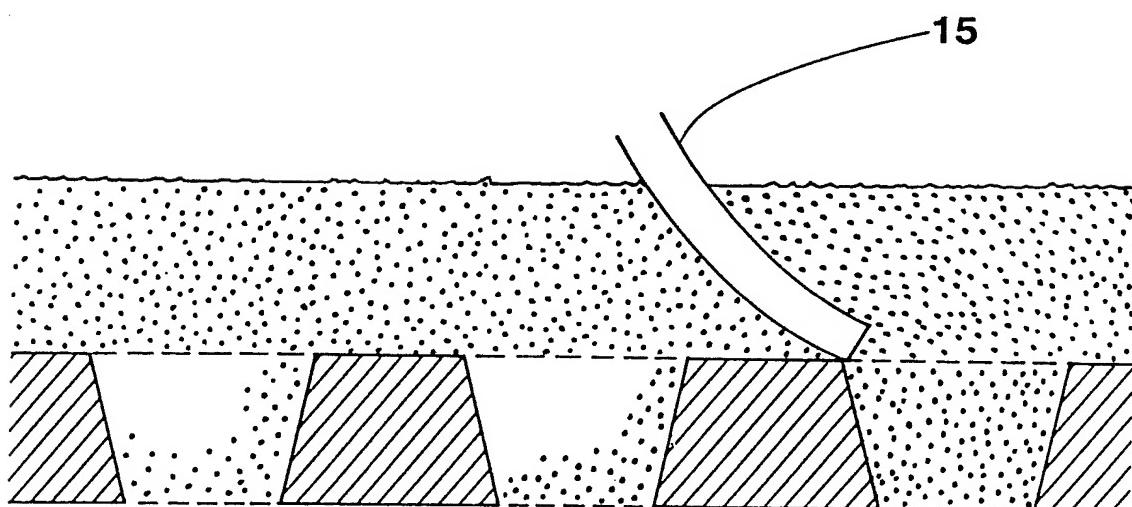


FIG. 3



DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. 5)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	US - A - 4 047 525 (KULESSA et al.) * Fig.; column 2, lines 28-60 *	1,4,9	A 61 M 15/00
A	GB - A - 2 041 763 (P. CHIESI, G. CITTERIO) * Totality *	1-3	
A	US - A - 2 587 215 (F.P. PRIESTLY) * Totality, especially fig. 7-11; column 4, line 52 - column 5, line 27 *	1-3	<p>TECHNICAL FIELDS SEARCHED (Int.Cl. 5)</p> <p>A 61 M 15/00</p>
			<p>CATEGORY OF CITED DOCUMENTS</p> <p>X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons</p> <p>&amp;: member of the same patent family, corresponding document</p>
X	The present search report has been drawn up for all claims		
Place of search	Date of completion of the search	Examiner	
VIENNA	14-10-1982	LUDWIG	